

## CLAIMS

Having thus described our invention in detail what we claim as new and desire to secure by the Letters Patent is:

- 1    1. A method of substantially reducing the number of tile or divot defects that are present  
2    in a silicon-on-insulator (SOI) substrate, said method comprising the steps of:  
3  
  
4    (a) implanting oxygen ions into a surface of a Si-containing substrate, said implanted  
5    oxygen ions having a concentration sufficient to form a buried oxide region during a  
6    subsequent annealing step; and  
7  
  
8    (b) annealing said substrate containing said implanted oxygen ions under conditions  
9    wherein said implanted oxygen ions form said buried oxide region which electrically  
10   isolates a superficial Si-containing layer from a bottom Si-containing layer, said  
11   superficial Si-containing layer having a top surface which contains a reduced number of  
12   tile or divot defects so as to allow optical detection of any other defect that has a lower  
13   density than the tile or divot defect.
  
- 1    2. The method of Claim 1 wherein step (a) comprises a single oxygen base implant or a  
2    base oxygen implant followed by a second oxygen implant, said second oxygen implant  
3    is carried out at a temperature lower than the base oxygen implant.
  
- 1    3. The method of Claim 2 wherein said second oxygen implant step is carried out using  
2    an oxygen dose of from about 1E14 to about 1E16 cm<sup>-2</sup> and at an energy of about 40  
3    keV or greater.
  
- 1    4. The method of Claim 3 wherein said second oxygen implant step is carried out using  
2    an oxygen dose of from about 1E15 to about 4E15 cm<sup>-2</sup> and at an energy of from about  
3    120 to about 450 keV.

1    5. The method of Claim 2 wherein said second oxygen implant step is carried out at a  
2    temperature of from about 4K to about 200°C at a beam current density of from about  
3    0.05 to about 10 mA cm<sup>-2</sup>.

1    6. The method of Claim 5 wherein said second oxygen implant step is carried out at a  
2    temperature of from about 25° to about 100°C at a beam current density of from about  
3    0.5 to about 5.0 mA cm<sup>-2</sup>.

1    7. The method of Claim 2 wherein said base oxygen implant comprises a high-dose  
2    oxygen implant which is carried out using an oxygen dose of about 4E17 cm<sup>-2</sup> or greater.

1    8. The method of Claim 7 wherein said high-dose oxygen implant is performed using an  
2    oxygen dose of from about 4E17 to about 4E18 cm<sup>-2</sup>.

1    9. The method of Claim 7 wherein said high-dose oxygen implant is carried out at an  
2    energy of from about 10 to about 1000 keV.

1    10. The method of Claim 9 wherein said high-dose oxygen implant is carried out at an  
2    energy of from about 120 to about 210 keV.

1    11. The method of Claim 7 wherein said high-dose oxygen implant is carried out at a  
2    temperature of from about 200° to about 800°C at a beam current density of from about  
3    0.05 to about 500 mA cm<sup>-2</sup>.

1    12. The method of Claim 11 wherein said high-dose oxygen implant is carried out at a  
2    temperature of from about 200° to about 600°C at a beam current density of from about  
3    4 to about 8 mA cm<sup>-2</sup>.

- 1    13. The method of Claim 2 wherein said base oxygen implant comprises a high-energy,  
2    high-dose oxygen implant which is carried out using an oxygen ion dose of about 4E17  
3     $\text{cm}^{-2}$  or greater and at an energy of about 60 keV or greater.
- 1    14. The method of Claim 13 wherein said high-energy, high-dose oxygen implant is  
2    carried out using an oxygen ion dose of from about 5E17 to about 7E17  $\text{cm}^{-2}$  and at an  
3    energy of from about 200 to about 500 keV.
- 1    15. The method of Claim 13 wherein said high-energy, high-dose oxygen implant is  
2    performed at a temperature of from about 100° to about 800°C at a beam current density  
3    of from about 0.05 to about 500  $\text{mA cm}^{-2}$ .
- 1    16. The method of Claim 15 wherein said high-energy, high-dose oxygen implant is  
2    performed at a temperature of from about 300° to about 700°C.
- 1    17. The method of Claim 2 wherein said base oxygen implant comprises a low-dose  
2    oxygen implant which is carried out using an oxygen dose of about 4E17  $\text{cm}^{-2}$  or less.
- 1    18. The method of Claim 17 wherein said low-dose oxygen implant is performed using  
2    an oxygen dose of from about 1E17 to about 3.9E17  $\text{cm}^{-2}$ .
- 1    19. The method of Claim 17 wherein said low-dose oxygen implant is carried out at an  
2    energy of from about 20 to about 10000 keV.
- 1    20. The method of Claim 19 wherein said low-dose oxygen implant is carried out at an  
2    energy of from about 100 to about 210 keV.
- 1    21. The method of Claim 17 wherein said low-dose oxygen implant is carried out at a  
2    temperature of from about 100° to about 800°C.

- 1    22. The method of Claim 21 wherein said low-dose oxygen implant is carried out at a  
2    temperature of from about 200° to about 650°C at a beam current density of from about  
3    0.05 to about 500 mA cm<sup>-2</sup>.
- 1    23. The method of Claim 1 wherein said annealing step is carried out in an ambient gas  
2    that comprises from about 0 to about 90% oxygen and from about 10 to about 100% of  
3    at least one high-surface mobility gas that hinders oxide growth, said high-mobility gas  
4    is selected from the group consisting of He, N<sub>2</sub>, Kr, H<sub>2</sub> and mixtures thereof.
- 1    24. The method of Claim 23 wherein said high-surface mobility gases is N<sub>2</sub>.
- 1    25. The method of Claim 23 wherein said high-surface mobility gas comprises 100%  
2    N<sub>2</sub>.
- 1    26. The method of Claim 23 wherein said high-surface mobility gas is admixed with Ar.
- 1    27. The method of Claim 23 wherein said annealing step is carried out at a temperature  
2    of from about 1250°C or greater for a time period of from about 1 to about 100 hours.
- 1    28. The method of Claim 27 wherein said annealing step is carried out at a temperature  
2    of from about 1300° to about 1350°C for a time period of from about 2 to about 24  
3    hours.
- 1    29. The method of Claim 23 wherein said annealing step includes a ramp and soak-  
2    heating regime.
- 1    30. The method of Claim 1 wherein said annealing step comprises the steps of: partially  
2    annealing the Si-containing substrate containing the implanted oxygen ions in oxygen so  
3    as to form a surface layer of oxygen on the Si-containing and to partially form said BOX

4 region; stripping the surface layer of oxygen; and continuing the annealing to complete  
5 formation of said BOX region.

1 31. The method of Claim 30 wherein said partially annealing is carried out in an  
2 ambient that comprises from about 1 to about 100% oxygen and from about 0 to about  
3 99% inert gas.

1 32. The method of Claim 31 wherein said inert gas comprises He, Ar, Kr, N<sub>2</sub> or  
2 mixtures thereof.

1 33. The method of Claim 31 wherein said gas comprises N<sub>2</sub> or a mixture of N<sub>2</sub> and Ar.

1 34. The method of Claim 30 wherein said partial annealing is performed at a  
2 temperature of from about 1250° to about 1400°C for a time period of from about 1 to  
3 about 100 hours.

1 35. The method of Claim 34 wherein said partial annealing is performed at a  
2 temperature of from about 1320° to about 1350°C for a time period of from about 2 to  
3 about 20 hours.

1 36. The method of Claim 30 wherein said surface layer of oxygen is removed utilizing a  
2 wet etch process that includes an etchant that has a high-selectivity for removing oxide  
3 compared with Si.

1 37. The method of Claim 30 wherein second anneal is performed at a temperature of  
2 from about 1250° to about 1400°C for a time period of from about 1 to about 100 hours.

1 38. The method of Claim 37 wherein said second anneal is performed at a temperature  
2 of from about 1320° to about 1350°C for a time period of from about 2 to about 20  
3 hours.

1       39. The method of Claim 30 wherein said second annealing is performed in an ambient  
2       gas that comprises from about 0 to about 90% oxygen and from about 10 to about 100%  
3       of at least one high-surface mobility gas that hinders oxide growth, said high-mobility  
4       gas is selected from the group consisting of He, N<sub>2</sub>, Kr, H<sub>2</sub> and mixtures thereof.

1       40. The method of Claim 1 further comprising applying a patterned resist to the surface  
2       of the SOI wafer prior to oxygen implantation.

1       41. A silicon-on-insulator (SOI) substrate comprising:

2  
3       a buried oxide region that is sandwiched between a superficial Si –containing layer and a  
4       bottom Si-containing layer, said superficial Si-containing layer having a top surface  
5       which contains a reduced number of tile or divot defects so as to allow optical detection  
6       of any other defect that has a lower density than the tile or divot defect.

1       42. The SOI substrate of Claim 41 wherein said buried oxide region has a uniform  
2       interface with said superficial Si-containing layer.

1       43. The SOI substrate of Claim 41 wherein said buried oxide region has an undulating  
2       defect-containing interface with said superficial Si-containing layer.

1       44. The SOI substrate of Claim 41 wherein said superficial Si-containing layer is  
2       smooth and has a glass-like appearance.

1       45. The SOI substrate of Claim 41 wherein said buried oxide region is present  
2       continuously through the substrate.

1       46. The SOI substrate of Claim 41 wherein said substrate comprises discrete and  
2       isolated buried oxide regions.

1    47. The SOI substrate of Claim 46 wherein some of said discrete and isolated buried  
2    oxide regions have an undulating defect-containing interface with said superficial Si-  
3    containing layer.

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